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COMPUTATIONAL ANALYSIS OF STEPPED AND STRAIGHT MICROCHANNEL HEAT SINK

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ABSTRACT

The microchannel has always been seen as the thrust area in the field of thermal research in mechanical engineering. The interest is focused on the computational analysis of linear and stepped type microchannel and the results are compared on the basis of CFD analysis performed. In this paper the best profile is chosen by comparing the results of both linear and stepped microchannel of 0.5mm width &1mm depth and varied width of 1mm, 0.8mm, 0.6mm & 1mm depth respectively; keeping the wetted area of both the profiles same. The inner and outer plenum of 5mm of square cross section. Tukerman and Pease were the pioneer in this field and were first to enlighten the concept of microchannel. The pressure, velocity, temperature and point parameters are analysed thoroughly using CAD/CAE software and the obtained result is performed on the test piece in the later stage.

Key words: Stepped Microchannel, Pressure Drop, CFD

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1. INTRODUCTION

The microchannel was pioneer by Tukerman and Pease [1] in early eighties was now a day's has become the thrust area of research for the scientist working in this field. The nature also has microscale cooling system in leaves of plants. The cooling is done by one phase and two phase flow. Single phase is studied extensively by Tukerman and Pease [2]. Now a day's heat is considered as the bad part for working of various electronic and

mechanical systems. To dissipate heat different scientist across the world are working hard to eradicate this problem and to provide cooling to the systems. There are different ways to do cooling to the systems which comes in contact with the heat. As S.G. Kandlikar [2], [3] researched that reducing channel dimensions yields larger surface area per volume and a larger heat transfer coefficient

The heat exchanger, microchannel, heat pipe are various devices which provide cooling to the system discussed by S.V. Garimella [4]. These devices have different application in different areas. The microchannel are used where the mechanical or electronic system requires efficient cooling in miniature. In this research paper the cooling is done by using liquid as fluid which is allowed to flow through microchannel. By taking thermal resistance into account as discussed by X Wei [5], the heat flux is another parameter which come into account. So in these two microchannel, the focus is kept on reducing the thermal resistance so that the desired value of heat flux can be obtained. The comparison is done between the straight microchannel and stepped microchannel by keeping the same wetted area. Heat transfer by fluid flow in microchannels can support very high heat fluxes that can be used in applications such as the thermal management of high performance electronics [7] In fluidic microsystems the microchnnnel with rectangular, trapezoidal and triangular sections has been used extensively Srinivas Garimella[8]. Most of the study is seen on circular or parallel microchannel as discussed by Masaki [9].

In microelectromechanical systems, very thin material can be cut by using EDM, ECM and chemical etching and high tolerance can be achieve by Kuo[10]. The mass transfer processes on the other hand take place in much smaller sized vessels, such as alveoli, which are on the order of a few micrometers, and form the air sacs at extremities of the air passageways in the lungs. The arterioles and venules, which are smallest vessels for blood transportation are only 10 to 15 µm in diameter [11]. Conventional techniques are applied in making the channels of 3 mm or larger hydraulic diameter. The channel sizes below about 3 mm are formed as narrow fin passages, as in plate-fin heat exchangers [11]. The innovative research of spiral microchannel performed by Vinay Aggarwal shows that the spiral profile of microchannel is much efficient in cooling the heated object. This technology can be used for future in supercomputers, spot- gun welding etc. The spiral microchannel technology is pioneered by Vinay Aggarwal which is quite helpful for future generations. In the research of spiral microchannel, when inlet is kept at inner spiral eye the pressure drop and temperature drop is less as compared to inlet at outer spiral eye [12]. In experimental work, when the fluids were (water+ water) and mixing angle was 600, it was observed that the pressure drop increases with the increases in flow rate [13].

2. COMPUTATIONAL ANALYSIS OF MICROCHANNEL PERFORMED

The 60mmx60mmx5mm block is design on Solid Works and inlet and outlet plenum of 5mmx5mm with depth of 1mm is made. First of all we design a linear channel with width of 1mm. The straight michrochannel has 40mm of length with inlet and outlet plenum of square shape 5mmx5mm. The depth of the entire microchannel is kept constant i.e. 1mm. On the other side the stepped microchannel is varied with different width at three different steps keeping the same wetted area in the entire steeped microchannel as kept in straight microchannel.

2.1. The Pressure contours in linear and stepped microchannel

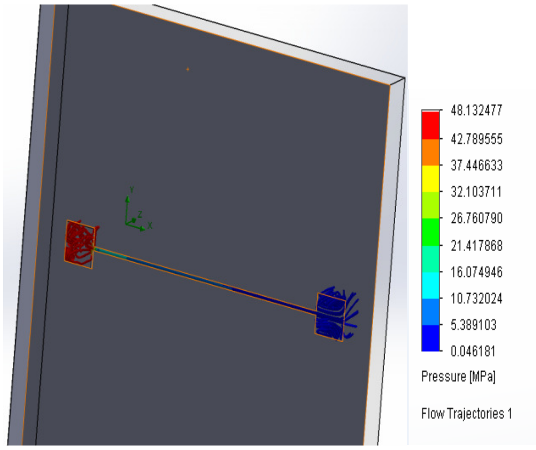

Figure 1 Pressure contour in linear (straight) shape profile

The three different widths in stepped microchannel are 1mm, 0.8mm, 0.6mm. The inlet and outlet plenum are very important to observe the thermal parameters like pressure drop, temperature drop and velocity parameters. The results can be improved by optimising the channel geometry and flow conditions. Simulation is done to analyse the result and to observe the thermal parameters in detail.

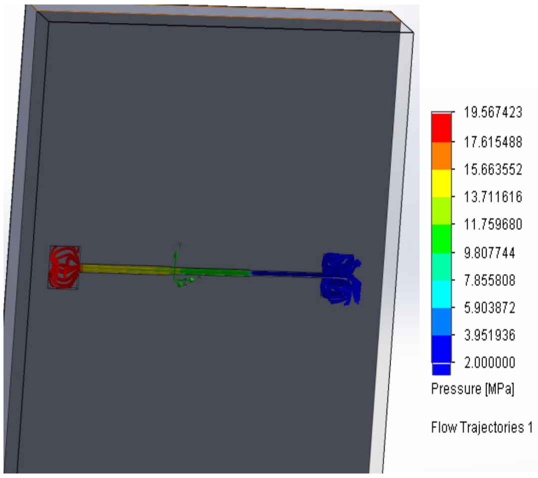

Figure 2 Pressure contour in stepped shape microchannel

2.2. Temperature contours in linear and stepped microchannel

The inlet flow rate of 3LPH (litre per hour) was kept when the heat source at 45W producing the much enough heat. The both the profiles were studied using Nusselt number and heat transfer coefficient 'h' and it was found that the straight microchannel is good in dissipating heat as compare to stepped microchannel.

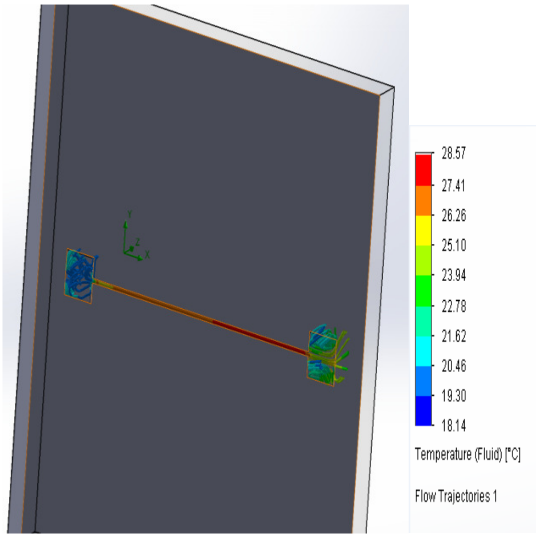

Figure 3 Temperature contour in linear shape profile

The data produced after the successful computational analysis was as follows, the Nu number was 2.45 and 3.02 ; the h was 1735 W/m^2K, 2139 W/m^2K of stepped and linear(straight) microchannel.

The stepped and spiral microchannel outlet temperature was observed to be 32.2 and 30.9 degree Celsius. This shows that the 1.3 degree Celsius difference between both the profiles. This difference is good enough to select the straight profile microchannel for more heat dissipation use.

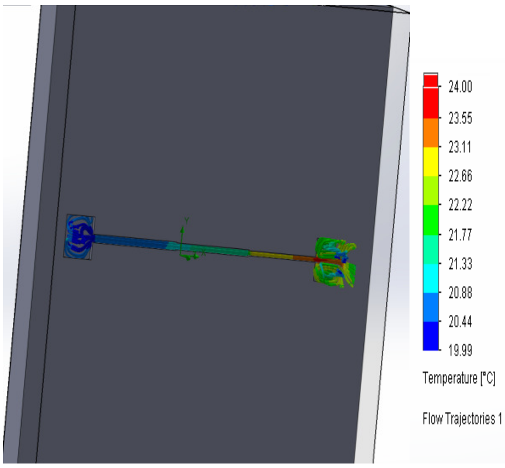

Figure 4 Temperature contour in stepped microchannel.

3. RESULTS AND DISCUSSION

3.1. Variation of pressure drop against Reynolds number

The heat source from the bottom surface was 45W and 60W as the input parameter for the linear shaped profile and the pressure drop is shown in below graph

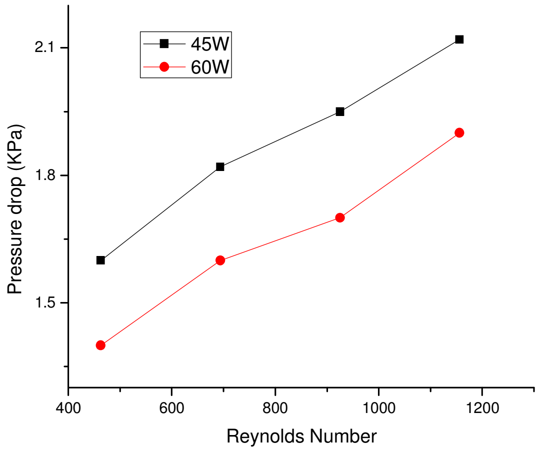

Figure 5 Pressure drop versus Re number graph of linear (straight) profile microchannel.

The post solution graph were obtained keeping the same input parameters for the varied shaped profile. The input heat source of 45W and 60W were provided and the trend of 45 W is seen as a little linear while the trend at 60W is seen as curve in shape.

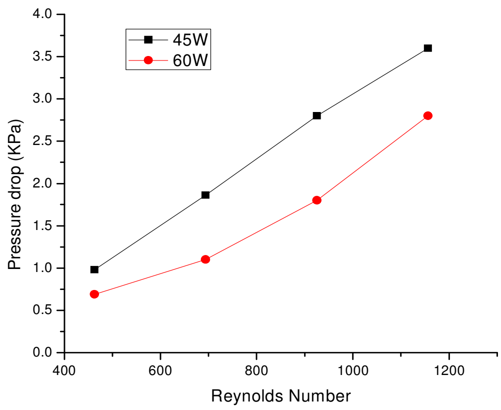

Figure 6 Pressure drop versus Re number graph of stepped profile microchannel.

3.2. Variation of pressure drop against Reynolds number

After the careful study it was observed that the Nusselt number variation is more in case of straight microchannel as compared to stepped microchannel. This proves that the heat transfer is more in case of straight microchannel as compare to the stepped microchannel. Nu number is more than 2 and goes upto 2.7 at varied Reynolds number in case of straight microchannel.

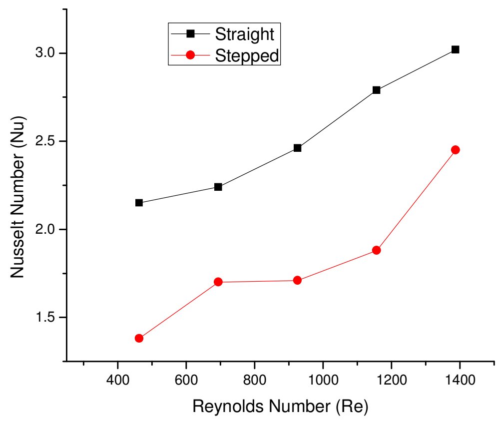

Figure 7 Nusselt number versus Reynold number at 45 W of straight and stepped microchannel.

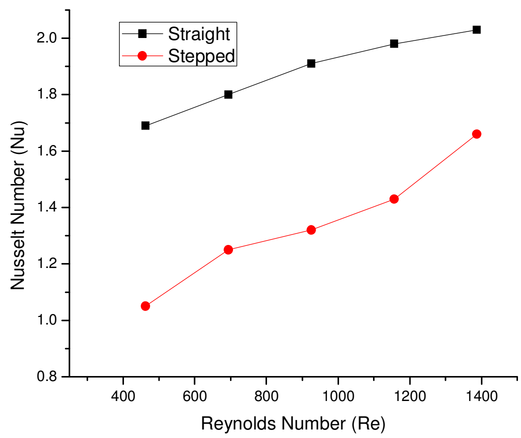

Figure 8 Nusselt number versus Reynold number at 60 W of straight and stepped microchannel.

The pressure drop of stepped microchannel is 5.01MPa and the pressure drop of straight microchannel 2.1MPa. Since from the result, it can be easily seen that the pressure drop in straight microchannel is less as compare to stepped microchannel. Hence the rate of heat transfer will be more in case of straight microchannel.

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